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THE CONTROL OF LOCAL CONFLICT

A Design Study

The Relevance of Factor Analysis

to the Study of

Arms Control and Limited War

ACDA/WEC-98 IV

Prepared for

The U.S. Arms Control and Disarmament Agency

Prepared by

Thomas C. O'Sullivan

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Center for International Studies
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THE RELEVANCE OF FACTOR
ANALYSIS TO THE STUDY OF
ARMS CONTROL AND LIMITED WAR

ABSTRACT

Factor analysis is one of a number of techniques (including agreement or configuration analysis) that provide for the orderly mathematical reduction of a large number of complex interrelationships to a smaller number of relations capable of explaining most of the behavior of the variables being studied. Given an analyst sufficiently knowledgeable in a substantive area, factor analysis provides him with a rigorous tool for isolating and interpreting the patterns of relations most relevant to the subject under examination.

Examples of applications of factor analysis in the study of cross-national data are reviewed, indicating, where possible, the data sources, variables used, and results of each study.

Discussions about the application of factor analysis to the study of arms control and limited war include the following possible uses:

- (1) identification of the most significant pressures (factors) that might be applied at pressure points to enhance or inhibit intensification or moderation in a conflict environment.
- (2) discrimination between factors in terms of their relative importance for specific nations or groups of nations.
- (3) specification of the direct and indirect means (policy actions) that might be employed in exercising the pressures.

- (4) measurement, in operational situations, of the levels of pressure existing in a given situation and across time (change analysis).

GENERAL DISCUSSION OF FACTOR ANALYSIS

Factor analysis, which has been applied so successfully in the field of psychology, is only one of the mathematical techniques of quantitative analysis for reducing a large body of complexly related data to a manageable set of representations which permits analytic interpretation. Each technique has its strengths; each its weaknesses; but each, in its own way, imparts order to a previously undefined set of relations, reducing them to a form that makes it easier (and in some cases possible) for the analyst to extract the meaningful patterns. Even so, the technique is less important than the competence of the analyst to select relevant variables and to interpret the results yielded by the technique.

In an application of factor analysis, we would start with a set of numerical data on variables measured across a number of data points. For example, say one wanted to investigate "attitudes about education." The analyst would first select a series of variables. These might include specific questions about how strongly a person (subject) feels about the importance of coeducation at the high school level; a survey of curriculum content in terms of seminar courses vs. textbook courses vs. laboratory courses, with the numbers weighted to reflect the relative proportions of each; questions on the optimum number of students in the schools of a given community, etc., for a total of 40 variables. To get data points, the analyst might consult 50 scholars, each of whom would supply a number for each variable. The number represents the measure, and how the measure is constructed

would depend upon the nature of the variable. For example, in the case of the first suggested variable, the analyst might construct a five-point scale representing a range from "coeducation is irrelevant" to "coeducation greatly assists the education process" from which the scholar (data point) would select the number most closely representing his point of view. Having obtained his measures, the analyst would then have a data base of 2,000 data elements composed of the measures of his 40 variables across his 50 data points.

Or, to take a topic more closely related to arms control questions: if the analyst were interested in investigating the bases of internal political stability, he might select 20 variables that seemed to him most relevantly associated with this phenomenon. (As these examples suggest, and as I mentioned earlier, the analyst's ability to select truly relevant variables is crucial to the successful application of factor analysis to any problem.) In this instance, the variables might include: the number of political parties, degree of modernization, per capita income, number of political arrests, number of assassinations, etc. (Some kinds of studies would permit the collection of "harder" data than would be accessible for the attitude study used as the first example.)

If the data on 20 variables (or characteristics) were collected across a group of 100 nations (data points), the result would be a data matrix of 2,000 data elements. As can be seen from Figure 1, a measure would then be computed for each pair of variables, representing the degree to which each pair behaved differently or similarly with respect to the data measurement of 100 nations. (The simple algebraic formula $\frac{n(n-1)}{2}$ expresses the number of pairs to be found in whatever number of variables (n) are being used.)

	V ₁	V ₂	V ₃	V ₄	V ₅	V ₆	-----	V ₂₀
1	----->	----->	----->	----->	----->			
2		----->	----->	----->	----->			
3			----->	----->	----->			
4				----->	----->	----->		
5					----->	----->		
100								

Figure 1. A Data Matrix from which Pair Correlation Coefficients Would Be Computed. Each Variable is Compared with all Other Variables.

Figure 2 shows the six pair-relationships that would be found in an intercorrelation matrix (the table showing the correlation between each variable and all others) that involved only four variables.

When the matrix is fairly small because the number of variables is low, it is possible to examine it, much as one examines a city-to-city mileage chart, to see whether the correlations suggest clusters of variables, or sets of clusters, that could identify the key forces operating in the process being studied. These clusters would be identified as factors, each factor being in effect an independent concept under which could be

1	2	3	4
	a	b	c
		d	e
			f

Figure 2. Intercorrelation Matrix for Four-Variable Problem.

subsumed a set of closely related variables capable of explaining a particular pattern of behavior.

As the number of variables increases, the factors describing the complex of behaviors among them may be more fully represented, but more difficult to identify because of the number of pairs to be considered. These increase exponentially: 4 variables involve only 6 pair comparisons; 8 variables result in 28 pair comparisons; 20 variables result in 190 pair comparisons; and 40 variables result in 780 pair comparisons.

When dealing with a large number of variables, then, the correlation matrix can be reduced, by factor analysis, to a smaller table showing the relations between each variable and the relevant factors as loadings or weightings. For the matrix using 20 variables,

the factor matrix might reduce the explanation of relations between the 20 variables to three or four factors capable of explaining 80 or 90 per cent of the behavior of the variables over the cases studied. Through examination of the factor loadings, the analyst can then interpret the meaning of the key factors.

(The mathematics involved in performing factor analysis are difficult to follow for anyone without mathematical training. Attempting to translate it into descriptive exposition, on the other hand, would take more time and space than the exercise merits, since I am trying only to establish the possible usefulness of the technique for research into arms-control questions, not to offer a short course in the technique itself. For anyone who wishes to inquire further into the mathematics, Benjamin Fruchter's Introduction to Factor Analysis [1] contains an excellent graphic representation of how it works.)*

The factor matrix for any two factors can be plotted on a graph showing the loading of each variable. In Figure 3, a set of hypothetical relationships has been graphed. The solid lines show one position of right-angle lines that represent the independent factors explaining the relationship between the variables. The locations of the variables relative to each other are a function of the correlations between them, and are mathematically derived through the application of factor analysis. If the variables are near each other, the correlation between them is significant.

*Those interested in further discussion of the technique should see Fruchter's first chapter. Sociologist Raymond B. Cattell also has an excellent book for interested analysts [11]. Cattell has split his discussion of factor analysis into three parts. First, in non-theoretical terms, he describes how factor analysis works. In Part II he discusses the mathematical theory. In Part III he provides a workbook for those who want to make their own application. This handbook for the user is mostly useful in giving the student practice. Many modern computer programs now exist so that the analyst need not go through the laborious hand computations. [Arabic numbers in brackets refer to entries in the bibliography following this paper.]

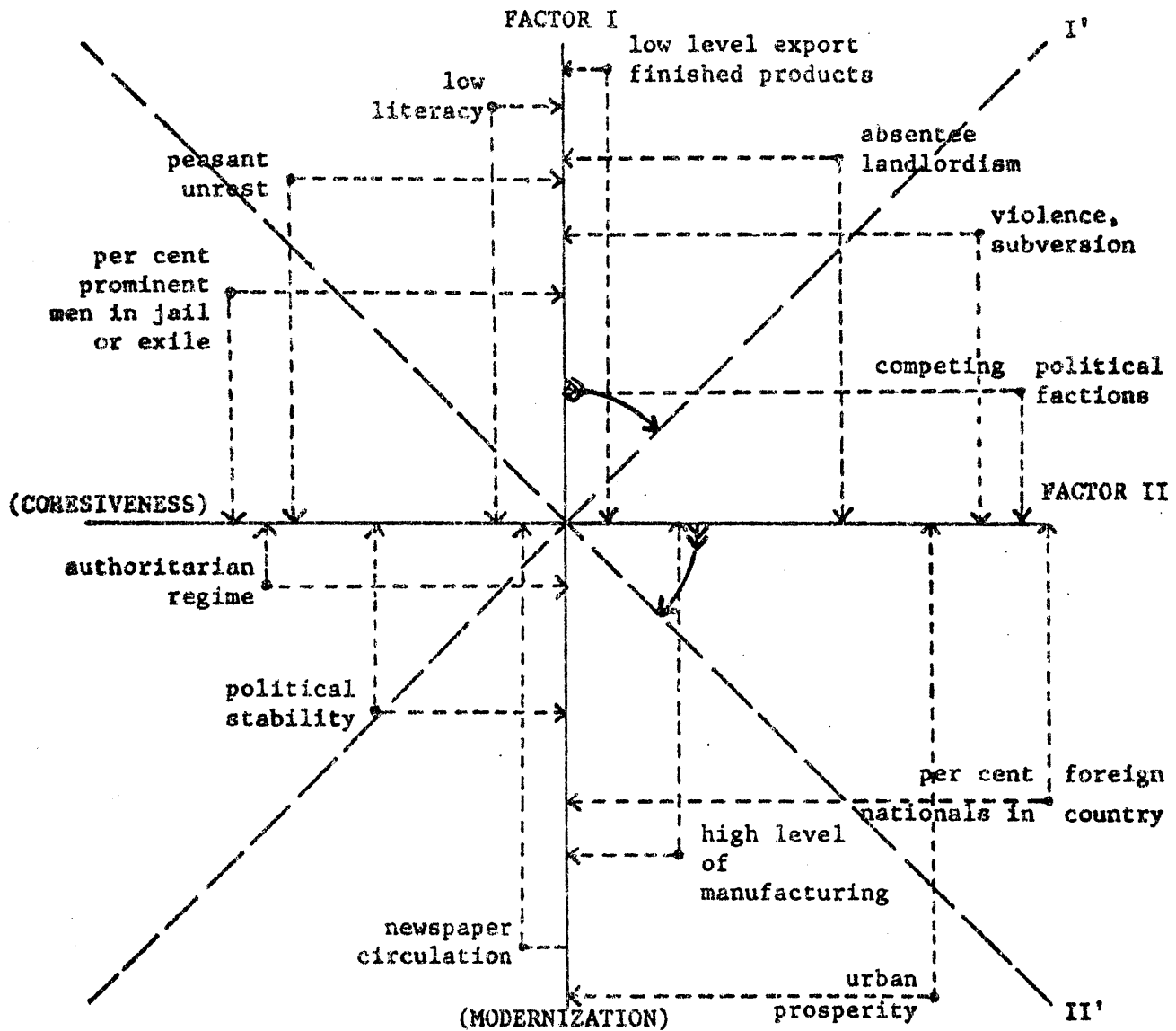


Figure 3. Variables Related to Modernization and Cohesiveness of Government.

By examination of the factor loading--that is, the length from the origin (where the two factor lines cross) to the point where the dotted line from the variable meets the factor line--an analyst may be able to interpret the meaning of the factor. Looking at Factor I in Figure 3, the analyst finds at the upper end a high positive loading for (that is, a high content of): low level of finished products exported; low level of literacy; absentee landlordism; and peasant unrest. At the other end of Factor I, he finds a high negative loading (tend to be absent when positively loaded variables are present) for: urban prosperity; high newspaper circulation; high level of manufacturing; and political stability. These variables might be interpreted as describing a modernization factor, with the positive end representing variables present in unmodernized countries and the negatively correlated variables representing either end-products of the modernization process or a combination of the modernization process with its end-products.

Factor II in Figure 3 is orthogonal (perpendicular) to Factor I, and therefore mathematically Factor II is independent of Factor I (that is, the projection of any point in space onto one factor is independent of its projection onto the other factor). Again, examining the graphic representation, we see that at one end Factor II shows high loadings for: per cent of foreign nationals in the country; competing political factions; urban prosperity; violence and subversion; and absentee landlordism. At the other end are high loadings for: per cent of prominent men in exile or prison; authoritarianism of regime; peasant unrest; and political stability. Factor II might be interpreted as describing the cohesiveness of government. The analyst, again drawing on his general knowledge of the field, might further postulate that the competing political factions could be a manifestation of the competing interests among the foreign nationals, the prosperous urban interests, and the rural interests of the absentee landlords.

Rotation of Factors

Factor analysis produces no unique solutions; that is, the same set of correlations can be presented in terms of an infinite number of factor sets. This process of slicing the same set of correlations along different factors is known as rotation. It does not change the relationships between the variables described; however, since it results in a different but non-conflicting representation of the same relationships, it permits the development of complementary bodies of theory to explain the same set of relations.

In Figure 4, the data of Figure 3 are shown with the lines of analysis shifted. The solid lines have moved to the position of the dashed lines of Figure 3. (This is an orthogonal rotation because lines representing the factors are kept at right angles to each other and therefore remain independent. Thus, if Factor I is rotated 40 degrees, Factor II must be rotated the same number of degrees.)

Figure 4 shows the new position of the factors. The variables are in the same position relative to each other. However, their projection onto the factors has changed. The analyst would then examine these new projections in an effort to define the factors. For Factor I in Figure 4, he might select political stability and for Factor II an urban-rural factor as independent from political stability and consistent with the high loadings of the associated variables.

The interpretations of both Figure 3 and Figure 4 are correct. They differ only in terms of the perspective from which the analyst viewed the relationships. The analyses are non-contradictory and complementary. It is like the choice of describing a bottle as half full or half empty. The selection of what rotation position to use is a matter of taste, or a matter of convenience in treating a

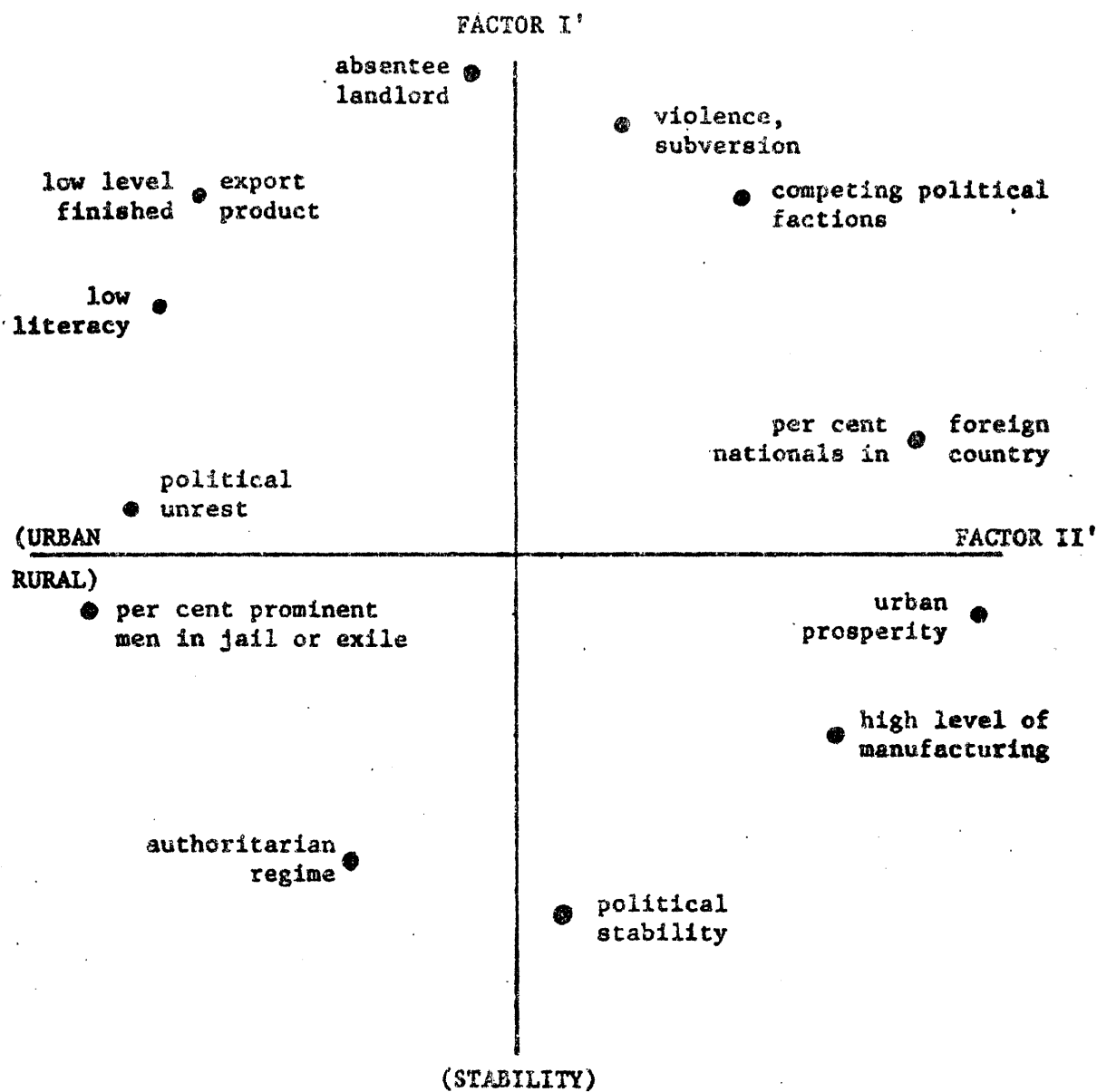


Figure 4. Rotation Position of Factors.

specific problem area or talking in the language of a specific discipline.

In some cases, factor analysis has been helpful in unifying separate bodies of theory that use the same body of data to support them. Factor analysis can show the spatial relationships between them and how they overlap and complement each other. In psychology and sociology, for example, factor analysis has been instrumental in providing a unified theory of personality and behavior that many specialists find reasonably convincing.

Validation of Conclusions

After the analyst has performed an analysis of a set of data, such as one of the two described above, he will wish to validate his descriptive factors. Two forms of validation may be required.

First, in order to validate his interpretation, he may wish to repeat the analysis including variables known to be highly significant correlates of the factors described. For example, for the cohesiveness of government he may wish to include variables indicating the degree to which conflicting political factions cooperate with one another, and other variables measuring the degree to which bureaucratic (rather than political) elements are competing for control, power, or authority. In repeating the analysis with these added variables, the degree of validation of the initial interpretation of factors would be a function of how appropriately the new variables load onto the factors.

Secondly, the analyst will be interested in the stability of his factor structure over time. To test this he can perform statistical analysis of the variables across the time his present analysis spans, or he can collect data for the same variables over a different time period and attempt to replicate his original findings using only the

new data. In the use of factor analysis for either form of validation, rotation of the factor space is necessary to find the closest fit to the original findings.

It cannot be too strongly emphasized that the technique of factor analysis, or any other technique of organizing complex bodies of data, does not substitute for the basic competence and insight of the analyst. If his grasp of the field is weak, narrow, or unimaginative, his interpretation will reflect this. The technique does nothing more than represent the manifestations of some body of theory. It is up to the analyst to extract the theory from the data presented, or to use the data to reinforce, validate, or contradict the theory.

GENERAL HISTORY OF THE GROWTH OF APPLICATIONS OF FACTOR ANALYSIS

Factor analysis was first developed in the field of psychology, where it is still used extensively. The earliest discussion of the technique was in a paper on human intelligence by Spearman in 1904 [23].* Little was done to expand this early work until World War II, when the military services gave impetus to the use and refinement of the technique in their search for a method to simplify and make more effective use of the psychological and placement tests administered to draftees and recruits. Psychologists are attempting, through its use, to narrow down to the lowest possible limits the number of tests that adequately describe and measure the functioning of the human mind.** At the same time, factor

*The following brief history is based on Harman's text [23] and describes developments beyond the early contributions made by Spearman, Holzinger, and Thurstone.

**See, for example, J. P. Guilford [21], Raymond B. Cattell [12], and John French [17]. Early examples of the same type of analysis are Spearman-Holzinger [26] and Thurstone [39].

analysis has been employed in the study of a wide variety of other psychological subjects -- temperament [22], executive morale [37], group behavior [6], and primitive societies [36].

But as Harman points out:

In recent years there has been an ever increasing application of factor analysis to fields other than psychology -- fields as varied as sociology and meteorology, political science and medicine, geography and business. A very brief overview discloses some exciting uses of factor analysis in arbitration between nations, conflict and economic variables in underdeveloped countries, and related studies by Harold Guetzkow and his students in the Program of Research in International Relations at Northwestern University. In a similar vein are a number of studies on the relationship of urbanization and economic development -- exemplified by such papers as Berry [5] and Gould [20], a report by Pitts [29] of a conference on Urban Systems Research in Underdeveloped and Advanced Economies, and a series of essays on "Geography and Economic Development" edited by Ginsberg [19]. An interesting adaptation of factor analysis to the study of municipal finance is made by Wood [42] as part of a very broad New York Metropolitan Region Study. Equally exciting have been the recent studies in physiology and medicine [e.g., 7, 14, 30, 34] especially concerned with cardiology and coronary artery diseases. Also, in such widely separated areas as meteorology [e.g., 3, 41], entomology [40], and advertising, and market research [13] investigators have come to appreciate the power and benefits to be reaped from this multivariate statistical technique. ([23], pp. 6-7)

Harman's discussion suggests the broad potential of this analytic tool for application to problems involving masses of data. In terms of its application to the field of arms control and limited war, only a few of the studies mentioned are of substantive interest.

FACTOR ANALYSIS OF NATIONAL AND CROSS-NATIONAL DATA

Even before the major emphasis on applications of factor analysis in psychology and sociology in the 1950s and 1960s, Cattell started to work with a larger body of cross-national data, trying to develop a description of cultural patterns and to account for the behavior of societies in terms of cultural forces. In this, he was attempting to explain national behavior in a manner analogous to explaining individual behavior in terms of personality traits.

Cattell's study [8, 9, 10] served as an inspiration to a number of scholars to follow. The logical flow of the studies in describing various elements of national behavior is shown in Figure 5.

Following closely on Cattell's first report, Hofstaetter [24], impressed by Cattell's work and curious about the nature of U.S. culture and its educational process, started work on a study of patterns of culture within the United States. In 1960, Berry [4] reported on regional factors of economic development; in 1961, Schnore [35] analyzed the modernization factor in economic development.

At about this time, Harold Guetzkow at Northwestern University was stimulating interest in the technique among the candidates for advanced degrees in political science. One of these students, Rudolph Rummel, undertook to identify the major elements explaining internal and external conflict behavior within and among nations. Rummel's work [31], published in 1963, is the earliest in the published literature to apply factor analysis to a large body of cross-national data related to conflict behavior. A year later, at San Diego State College, Hoole [27] produced a Master's thesis analyzing political stability and instability as related to internal conflict in nations.

In September 1963 Hayward Alker delivered a paper at the

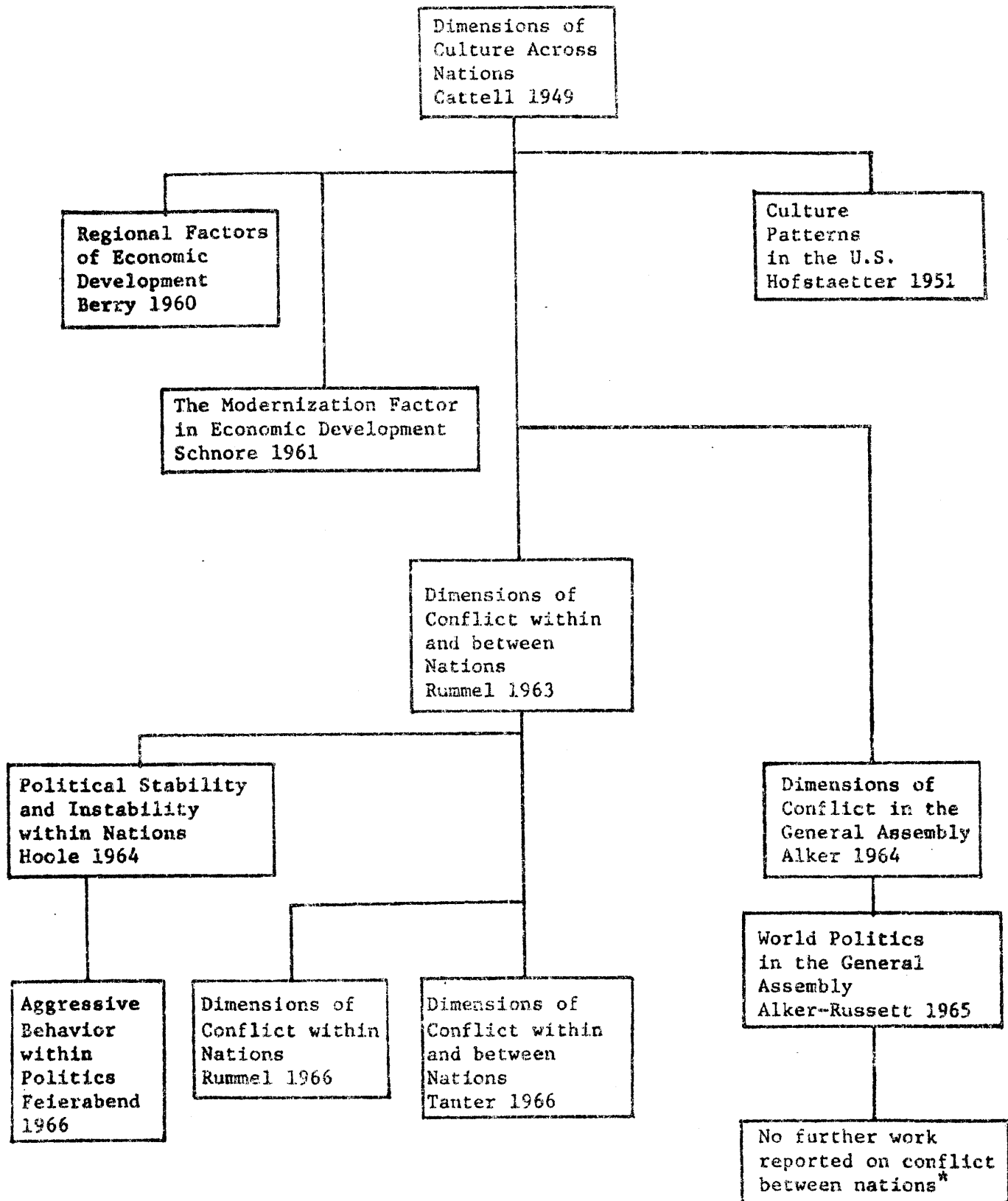


Figure 5. Factor Analytic Studies of National and Cross-National Data.

*With the important exception of Rummel's [33] description of work now in progress at the Dimensionality of Nations Project at Yale.

Annual Meeting of the American Political Science Association, published [2] in 1964 in a later version, in which he examined the pattern of national voting in the General Assembly. A year later Alker and Bruce Russett published [3] a substantial analysis of international political process under the title World Politics in the General Assembly. In this publication, they summarized their use of factor analysis to explore this problem area. Their main points are:

- (1) The factors can provide a clear and objective way of summarizing the main components of voting in the United Nations.
- (2) All important General Assembly roll calls can be included in such an analysis. Entries in the factor pattern tell how much of the voting on each roll call can be explained by each factor.
- (3) Plotting factor scores of each of the voting nations on each factor will allow us to see how cohesive members of the different groups are, as well as the direction of dissent of deviant members.
- (4) Such plots allow easy simultaneous consideration of the locations of all the participating states.
- (5) "Because the roll calls in a factor pattern may be identified as to substantive content, and because we have explicit measures of the positions of different states on the separate factors, it will be relatively easy to compare factors from year to year to see how many substantive and alignment changes have occurred in them, and what the trends have been regarding particular issues or general factors."
- (6) "The amount of variance explained by the factors gives a precise measure of the frequency or relative prominence of the main super-issues before the General Assembly. With such information, for example, we can see whether or not the cold war or colonialism has increasingly

preoccupied the United Nations. Measures of the importance of these and other issues for individual states will require additional information."

Meanwhile, Rummel, eager to validate his earlier work, used a set of data [XXV]* collected by Eckstein [15] to examine internal conflict behavior over a different time period. This work was reported in 1966 [32]. At the same time, Tanter [38] reported on his efforts to replicate Rummel's complete earlier study, using the same data sources and a different, but contiguous time period.

Using an expanded version of the Tanter data, Feierabend, et al., performed another factor analysis of internal conflict behavior. This study begins to carry the analysis beyond a purely descriptive (classification) application. In Feierabend's report on this work he says, "Once political stability variables data were collected and analyzed, seeking correlates of instability became feasible." [16]

Although these early studies on the nature of conflict laid the basis for isolating the key factors in conflict control, the work has not been extended in the direction of permitting the selection of appropriate policy measures for conflict control. Such extension requires careful planning. The analysts' major contribution, to this point in time, has been the demonstration that factor analysis can be used to understand conflict control. Because of this contribution, the studies identified above will be descriptively summarized in terms of the nature of the inquiry, the source of the data, and the results of the analysis, including the factors identified and the variables associated with each factor.

*Roman numerals within brackets indicate references in the Appendix, indicating sources of information used in factor analysis of national and cross-national data.

Cattell [8, 9, 10]

Looking for factors to explain the behavior of cultures that would be similar (or parallel) to personality traits that are used to predict the behavior of individuals, Cattell collected data on 69 nations, using a total of 82 variables. The variables represented three classes of information: mean characteristics of population; characteristics of the group (i.e., government and other institutions); behavior of the group (i.e., number of treaties, frequency of war, etc.). The specific variables to be used were selected after an extensive search by Henry Bruel and Helen Parker Hartman of relevant literature on the nature of societies [I-X].

The published papers do not identify the source of the specific numbers used in the study. Cattell indicates however that in general he used data obtained from field workers, UNESCO [X], and the U.S. Department of State [XI]. He does not indicate precisely what documents he obtained from the last two sources, or whether these data were drawn from published materials or interviews. Where information was not available on "psychological" variables, estimates were made from indirect indicators of the variable of interest [XII]. For example, interest in religion was estimated on the basis of the percentage of religious men among eminent men. The degree of restriction on sexual behavior was estimated on the basis of information on the degree to which the society was polygamous, the freedom of legal divorce, and the degree to which prostitution was legalized.

Because of unreliability of data, overlap between variables, and other causes, 10 variables were dropped, leaving 72 variables across 69 nations. Many variables were measured over a 100-year span, 1837-1937. Some variables were taken over a 10-year span (e.g., number of Nobel Prize winners).

Although twelve factors were identified, the work was done in a fashion to allow the factors to be related (as opposed to identifying factors completely independent of each other, as is the case in most of the studies to be discussed). The first six factors and the variables most directly associated with them are listed below:

<u>Factor</u>	<u>Variables Associated</u>
I. Size	Large gross area; many political assassinations; few cities over 20,000; large gross population; many riots
II. Cultural Pressure vs. Direct Ergic Expression	Many cities greater than 20,000; high ratio tertiary/primary occupation; high frequency political clashes with other countries; many Nobel Prizes
III. Enlightened Affluence vs. Narrow Poverty	Low TB death rate; large gross area; high expenditure of tourists abroad; high standard of living
IV. Conservative Patriarchal Solidarity vs. Ferment of Release	Low per cent political eminent among eminent; low number telephones; high per cent population maintained by military forces; high restriction of divorce
V. Emancipated Urban Rationalism vs. Unsophisticated Stability	High death rate from cancer high per cent politically eminent among eminent; high number of telephones
VI. Thoughtful Industriousness vs. Emotionality	High number of deaths by homicide; low number of political assassinations; high per cent population in trade unions

Other factors included: VII. Vigorous Self-Willed Order vs. Unadapted Perseveration; VIII. Bourgeois Philistinism vs. Richless Bohemianism; IX. Residual or Peaceful Progressiveness; X. Fastidiousness vs. Forcefulness; XI. Buddhism - Mongolism; XII. Poor Cultural Integration and Morale vs. Good Internal Morality.

Cattell observed that, other than Factor XI, there were no racial or religious factors. The others seemed to separate into four classes: demographic, economic, historical development trends, and psychodynamic processes or conditions.

In his second report on this pioneering work [9], Cattell, using the same analysis, took the next step by examining the patterns of nations as they show how much of each factor they hold, that is, how much of a nation's total behavior can be explained by each factor. In examining these patterns, he noted that the 69 nations tended to form nine distinct patterns; he identified nine distinct families of cultural patterns. Some of the most important (powerful) nations did not fall into any of the patterns. They had individual patterns of their own.

In Cattell's third report on his work [8], a new factor analysis is described. In it he used the original data but dropped 29 nations to increase reliability and focus on nations of primary interest. In this work, five of the factors from the previous work remain unmodified: Enlightened Affluence, Cultural Pressure, Vigorous Order, Size, and Morale. He observes that three of these suggest well-known personality traits: mental capacity, second-order rigidity, and personality integration.

Hofstaetter [25]

Although inspired by Cattell's work, Hofstaetter thought it had been too ambitious. He set out on a more modest task to look at sixteen variables across the 48 U.S. states. As sources of information he used Kiernan's 1951 Information Please Almanac [XIII] and the U.S. Department of Commerce 1948 Statistical Abstract of the U.S. [XIV]. In processing his data, he identified three factors which explained 65 per cent. of the relationships between the data:

<u>Factors</u>	<u>Variables</u>
I. Urban Comfort vs. Rural Fertility	High per cent urban population; high per capita income; high teachers' salary; high per cent white families; low level of larceny; low birth rate; low per cent students in total population
II. Emphasis on Education	High per cent of attendance at school; high number of years school completed by population over 25 years old; high \$/pupil expended; high level of government employees; high per capita income; high level of larceny
III. Absence of Racial Discrimination	High negro/white years of school completed; high per cent white families; high number of teachers in elementary schools

Following through on the factor analysis, Hofstaetter examined the patterns of factor scores that various states had on each factor. When correlation is performed in preparation for factor analysis, the detailed information about the data points (in this case the measurements of each variable on each state) is suppressed. This detail remains implicit in the results. Mathematically the information may be reconstructed. One form of reconstruction is the description of the content each state has in each factor. This is called a factor score (as opposed to the factor loading representing the content each variables has in each factor). This type of analysis is similar to that performed by Cattell in looking at families of nations; however, in his article Hofstaetter used a few examples rather than develop general families of states. The scores for six states that seem to fall into two general patterns are illustrated in Figure 6. Note that Utah has no score on Factors I and III; it seems to be a pure example of Emphasis on Education.

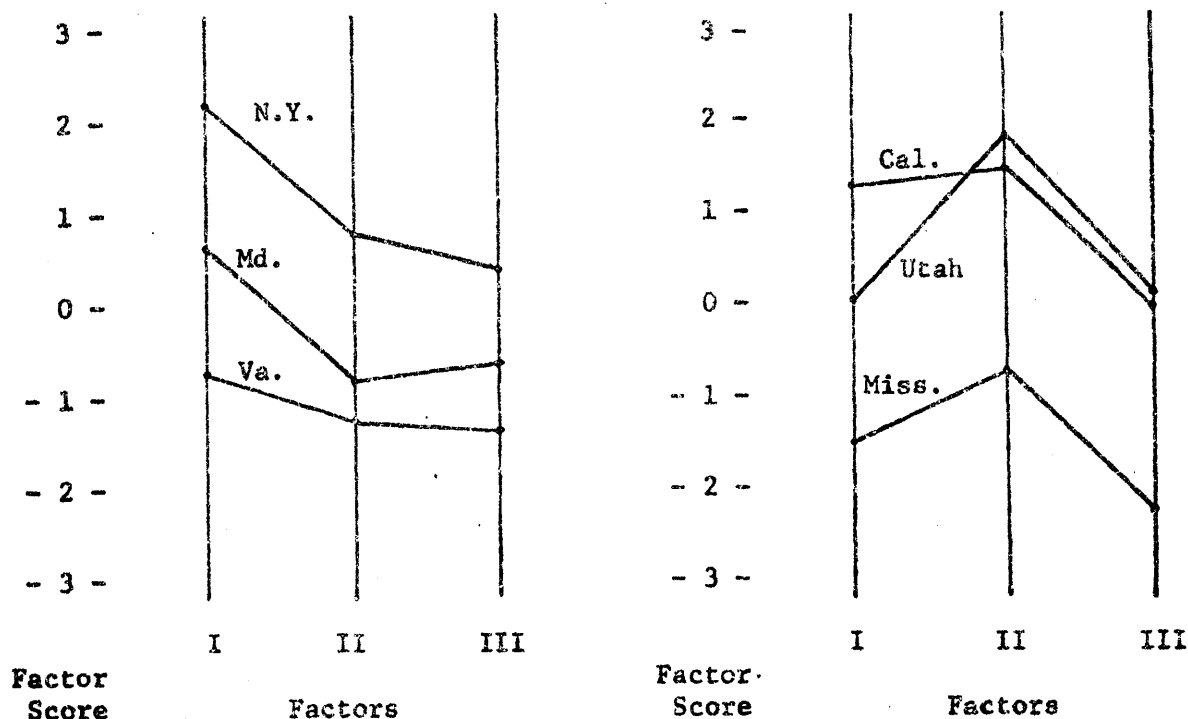


Figure 6. Factor Scores of States on Hofstaetter's Factors.

Schnore [35]

In 1961 Schnore reported on his work on statistical measurements of urbanization and economic development. He assembled data on 75 countries covering 70-80 per cent of the world, excluding China. As sources he used various U.N. publications[XV-XIX] (although he was not always specific about the exact sources) and Valacras' work on young and aged populations reported in the Annals of the American Academy of Political and Social Science [XX].

Schnore examined his results without rotating the factor space, noting that the variables were tightly clustered around a single factor which he calls modernization. The variables he used included per capita consumption of income, motor vehicles per capita, newspaper circulation per thousand, males occupied in non-extractive pursuits, per

capita volume of imports and exports, per capita income, number of physicians and surgeons per thousand, per cent literate population, per cent population change between last two censuses, age composition, urbanization, and metropolitanization.

Schnore was critical of Cattell for interpreting his factors and refused to label his, feeling that he had discovered a clear single factor of modernization. He cautioned that the arbitrary location of a factor in space may not represent any real substantive phenomenon. But by settling for an arbitrary location of the factor in his own study, Schnore may have failed to exploit the technique fully. Through rotation of the factors he might have been able to separate the cluster into two factors. A quick look at the loadings he reports suggests that he might have been able to separate his modernization factor into urban prosperity and transportation-communication.

Rummel [3]

For his study of the conflict behavior between and within nations, Rummel selected 22 variables, with 77 nations as data points. Nine variables represented domestic conflict and 13 external conflict. Data were collected for the years of 1955-1957 from four sources: The New York Times Index, the New International Yearbook, Facts on File, and Britannica Book of the Year [XXI - XXIV]. Kessing's Contemporary Archives were used initially but dropped when they were found to be inadequate.

Rummel identified three internal and three key international conflict factors. The variables associated with them are listed below:

<u>Domestic Conflict Factors</u>	<u>Variables</u>
I. Turmoil	Assassinations, strikes, government crises, riots, anti-government demonstrations

II. Revolution	Strikes, purges, revolution, number of domestic killings
III. Subversion	Assassinations, guerrilla war
<u>External Conflict Factors</u>	<u>Variables</u>
I. War	Protests, threats, military action, mobilization, accusation, number killed
II. Diplomacy	Troop movement, expel and recall ambassadors and other diplomats
III. Belligerency	Anti-foreign demonstrations, negative sanctions, sever diplomatic relations, military action

In the countries that experienced internal conflicts, Rummel found Turmoil to be an associated factor in France, Argentina, India, Pakistan, Guatemala, and Haiti; Revolution in Argentina, Communist China, India, Guatemala, Brazil, and Paraguay; and Subversion in Cuba, Burma, the Philippines, Argentina, Indonesia, and Colombia.

In cases of external conflict, War was a factor associated with Israel, Egypt, France, the United Kingdom, Hungary, and the U.S.S.R.; Diplomacy was associated with the U.S.S.R., the U.S., the Dominican Republic, Argentina, and Venezuela; and Belligerency appeared in the cases of Egypt, Jordan, Pakistan, Afghanistan, Chile, and the Republic of China.

Hoole [27]

Hoole's San Diego State College Master's thesis on political stability and instability within nations was not available at the time this paper was being prepared. References in the literature indicate that the study was a factor analysis of 30 variables using data from Deadline Data [XXV] for the years 1948-1952.

The study identified five major and five minor factors associated with political stability and instability. The five major factors were: I. Demonstration; II. Change in officeholders; III. Riots; IV. Guerrilla Warfare; V. Strikes.

Alker [2]*

Alker used 70 important votes at the 16th General Assembly, including all distinct, non-unanimous, non-procedural, plenary roll calls, as well as 26 of the most important committee votes, as his variables; his data points were the member nations.

The unrotated factor matrix brought out two clear factors: East vs. West, and North vs. South. The rotated factor scores brought out the factors of Self-determination, Cold War, Moslem Questions, and U.N. Supranationalism.

Further analysis of data associated with the voting nations showed correlates between the factors and various environmental variables from the areas of economics, politics, and sociology. There was a high relationship between the Self-determination factor and: per capita income, degree of alliance with the United States, democracy, colonial power since 1917, ex-colony since 1917, per cent European descent, and per cent Negro.

There was a high relationship between the factor of U.N. Supranationalism and: per cent trade with the United States, United Kingdom, and France; per cent trade with the Soviet bloc; Communist states; totalitarian regimes; and per cent European descent.

*See also Alker and Russett [3] for a substantial extension of this work to world political process.

Rummel [30]

Using twelve variables of domestic conflict, Rummel factor analyzed Eckstein's data [XXV]. This study, covering the years 1946-1949, produced the same factor structure as Rummel's earlier work, isolating Revolution, Turmoil, and Subversion as three distinct internal conflict factors. These factors were independent of each other. This quality of independence does not mean that the factors do not coexist in the same state but simply that in differing situations they may vary independently of each other.

Tanter [38]

While Rummel was working on the validation of his previous work on domestic conflict, Tanter attempted to replicate the whole of Rummel's previous work. Using the same variables, he collected data for 1950-1960; the same data sources were used except that Deadline Data on World Affairs [XXVI] was substituted for the New International Yearbook [XXII]. Tanter found the same factor structure for external conflict, with the factors of Diplomacy and War switching in order of importance, Diplomacy taking the most important position and War the second most important. Belligerency remained in the third position.

The factor structure for domestic conflict produced only two factors. Rummel's Turmoil factor reappeared. Tanter's second factor, Internal War, subsumed Rummel's Revolution and Subversion factors. This result partly substantiated Rummel's results by maintaining two general classes of variables--organized conflict and unorganized conflict.

Feierabend [16]

Feierabend and his associates collected data for the period 1948-1962 on 30 variables, representing aggressive behavior within

nations, from Deadline Data on World Affairs [XXVI] and the Britannica Book of the Year [XXIV]. Factor analysis yielded nine factors explaining 71 per cent of the behavior of the variables. The first three factors accounted for about 38 per cent of the total variance. The factors and their associated variables are listed below:

<u>Factors</u>	<u>Variables</u>
I. Turmoil	Large strikes, small and large demonstrations, small and large riots, mass arrest of insignificant persons, terror and sabotage
II. Palace Revolution and Revolt	Repressive action against specific groups, arrests but no imprisonment of significant persons, martial law, coup d'etat, revolt
III. Power Struggle or Purge	Vacation and acquisition of office, arrest and imprisonment of significant persons, execution of significant and insignificant persons

The other six factors were Riots, Elections, Demonstration, Imprisonment, Civil War, and Guerrilla Warfare.

Having analyzed the factors for aggressive behavior within polities, the analysts started seeking the correlates of instability. First, using measures based on previous studies, countries were rated as stable or unstable. A measure was developed of systemic frustration (ratio of want formation to want satisfaction). It was found that the higher the level of systemic frustration in a nation, the greater the political instability. The various indicators of want formation and want satisfaction were evaluated in terms of their efficiency as indicators or predictors of stability. Thresholds for indicators, above which countries are predominantly stable, were established.

A dynamic study over time considered the relationship between

rate of change and stability. Countries were rated both in terms of the level of yearly fluctuation of stability and the quality of the change (whether or not there was a worsening trend). Those countries with the lowest rating of change were the most stable.

No further studies of direct relevance to arms-control research were found. However, a clear trail has been identified. A good start has been made on study of domestic conflict, but only enough to demonstrate that the factor analytic technique can be applied to arms-control studies. First, however, further work needs to be done on the factors operating in external and international conflict. All such work would probably be of value to the narrower question of the use of arms-control techniques to control local conflicts. Its relevance to this aspect of the general arms-control problem will be enhanced to the extent that conflicts in the developing world are included in the cases from which data are drawn.

THE APPLICATION OF FACTOR ANALYSIS TO ARMS CONTROL

The early work on conflict did not cover a broad enough spectrum of conflict, nor probe deeply enough into the correlates of conflict and military-political stability, to have operational applicability to arms control. Substantial additional research would have to be done, first of all on conflict control.

In the balance of this section, I point out the specific subjects that would have to be analyzed, consecutively, in order to develop a systematic set of policy actions aimed at control of limited conflicts. In the process, I am merely outlining boldly the scope of the problems that would have to be considered, and possible approaches to them. Obviously, whether my assumed priorities are accurate---or

even whether the actual research would yield results that could be put to practical application--would be determined only as the research proceeded in fact rather than in blueprint.

First priority should be given to two kinds of research, both aimed at getting operationally useful results. The results could be used to perform trend analysis to identify developing conflict situations within or between nations and to select specific policy actions either to strengthen or change trends identified.

For each of these operations, a predictive technique must be developed. In the first case, we must be able to predict the course of history if no policy intervention is attempted. In the second case, we must be able to predict the specific effects of possible policy actions not only on the nation or area where change or reinforcement is desired but also on other nations or areas where we might not wish to effect any change.

Henrysson discusses the use of factor analysis in developing predictors:

The selection of tests for prediction gives illustrative examples of the problems that arise when looking for suitable descriptive variables, and of the aid factor analysis can render. There are two types of problems of prediction to be discussed in this connection: direct prediction and differential prediction. The purpose of direct prediction is to predict, with the greatest possible validity, the subject's results in a certain field. The selection of personnel for a certain job, or of pupils for a certain type of training, are examples of this. Often the same set of predictors should be used for direct prediction in many fields at the same time...For this purpose, a number of tests are needed, which are chosen in such a way that they give, in a simple manner, the best possible prediction of results in all the jobs mentioned. From a psychometric viewpoint, the problem may be said to consist in finding a limited number of tests that, weighted together

with suitable weights, give maximum correlations with criterions of success in respective jobs. The problem of differential prediction arises when a limited number of people are to be given different jobs according to assigned quotas, so that the total sum of job results is maximized. ([24], p. 60)

Conflict Behavior Patterns

Transferred to the problem of arms-control research, the job classification function would be analagous to the problems of classifying nations into general behavior classes in terms of their conflict factor pattern. This function of classification is what most of the studies in the previous section represent, i.e., the location of and interpretation of the descriptive factors (of culture or of conflict). Each class or conflict family would have a distinct pattern of behavior described in terms of how much each conflict factor was represented in the nations of a group. This task is similar to Cattell's and Hofstaetter's work in isolating cultural patterns and clustering nations and states in terms of their factor scores on each of the significant factors.

Work reported to date would need extensive development to meet the research needs in arms control. Continuation of the Rummel line of work in the direction of the Feierabend study, incorporating such variables as a nation's inclination to intensify or moderate conflict for each year, degree of foreign involvement in internal affairs, alliance index, and other measures that could be a function of U.S. policy actions.

The level of detail to which classification is carried is arbitrary. Too fine a separation will produce little grouping, with the result that the analyst defines too many classes. If the separation is too gross, relatively unlike nations will be grouped together, and it will be difficult to use the groupings to select policy actions that will have

differential effects on the nations. No clear technique or guideline has been developed beyond using a measure or threshold value of likeness, which in itself is an arbitrary value.

More work has been reported in exploring the description of domestic conflict than of inter-nation conflict. Rummel's initial study and Tanter's later validation of the external conflict variables have not been followed up in the same way that Feierabend has followed on the internal conflict variables.* An integrated approach to both areas should be undertaken, including an attempt to see if families of conflict behavior cluster nations together in a way that tends to carry them across both internal and external conflict patterns.

Analysis of Conflict Content

Classification of national conflict behavior patterns is a descriptive use of factor analysis, not necessarily oriented toward operational content. It will probably be necessary to perform further analysis of each classification or grouping of national conflict behavior, comparable to Henrysson's job analysis, in order to do a thorough investigation of what the correlates to inhibiting conflict would be, with special emphasis on those conditions that can be controlled or affected by specific U.S. policy action. Work such as the Feierabend work on the correlates to political stability suggests the kind of research necessary. It must include analysis of the degree of efficiency of these control points in inhibiting the growth or expansion of conflict. The areas of control should include political, economic, and military elements in the nations within each class. As in the descriptive case, the attempt would be to reduce a large number of elements of conflict control to a small number of independent descriptors that account for a large per cent of conflict behavior.

*Except as reported by Alker and Russett [1,2] on inter-nation politics, and as being worked on by Rummel, et al. [34] at Yale.

Policy Selection

The identification of policy actions that can elicit the desired response in a nation has in it, as a research task, elements analogous to the problem of test construction. We need to identify policy actions that have in them a high content of the desired conflict-control factors. Following the line of factor analysis that leads to direct prediction would seem the most promising direction toward identifying policy actions that have a general effect of controlling conflict.

A large number of policy measures of a given kind could be used to determine the effect of that particular type of action. First, data would be collected, including the key variables associated with the conflict-control factors. These data would be measured at the time that the policy measure was in effect. The analysts would rate the degree to which the policy measure was present. Correlation analysis and factor analysis would be performed with rotation of the factor space to replicate the conflict-control factors. Thus measurements could be obtained that showed how each conflict-control factor was associated with the policy action. By including a number of different types of policy action and rating the relative presence of each action in each situation where other data were taken, the relative effectiveness of each type of policy measure could be determined. It is possible, though not probable, that policy actions could be identified that would have a pure effect on each conflict-control factor. It is more likely that each policy action would have a pattern of effects on the various conflict-control factors. In this case the analyst should look for a pattern similar to the pattern for the several conflict behavior patterns. If this does not exist, then a policy action mix should be sought to bring about the desired mix of control features.

A similar analysis could be made of the effects of arms-control measures on a nation's freedom to exercise policy actions relevant to conflict control. While there have only been a few examples of arms control, it may be possible to identify independent action by influential or powerful nations which has had constraining effects similar to those that would be imposed by arms-control agreements. The effects of these independent actions could then be studied to identify the effects of corresponding arms-control measures either on the freedom to exercise policy or directly on conflict control.

Differential Prediction

It is not clear how effectively factor analysis can be applied to the area of differential prediction. The problem is that while we may be able to identify a policy mix for a given situation, each policy action has a multiple effect. It has a direct effect on the situation of interest; it may have a side effect on other situations. For example, a policy action directed at Cuba or the Soviet Union during the 1962 missile crisis might have had side effects in Berlin, Paris, or Vietnam. A policy action directed at the Suez crisis of 1956 could have had side effects in Budapest, Algiers, or the offshore islands of China.

Thus, in order to determine the total impact of a policy action, it should be considered not only in the situation where it is directed but also in other situations. Such differential analyses could be made, but they would involve massive amounts of data to be handled. Factor analysis might be used as a brute-force technique to reduce the number of interrelationships to be considered. Even so, the resulting analysis requirements would be substantial. If we had five different types of policy action under consideration, and used a set of only 40 nations, we would need 200 measurements representing the degree of presence of each type of policy action in each of the 40 nations. How these data could be measured is uncertain. If measurable, the factor analysis could

be performed and, through rotation, the factor space could separate the variables along the conflict-control dimension by using the conflict-control variables as a reference to replicate the control factors. Then the relative importance of each type of policy action for each conflict-control factor could be determined. This in itself could prove useful. The meaning of the factor scores of nations in this case is, however, less clear.

A detailed research design for this task should include as an early priority the interpretation, in terms of statistical theory, of the groupings or classification of nations. Other organizations of data might be considered.

Change Analysis

If we succeeded in establishing the key factors involved in conflict control, it would be possible to establish a continuing analysis of the "conflict content" or "potential" of specific situations. In order effectively to perform this function, it would be necessary to develop predictors for determining the presence of conflict-building or stabilizing elements. It is not clear that factor analysis is the proper technique here. Having established the dimensions of conflict control, other statistical techniques might be more suitable for selecting the indicators or predictors. Again pointing to the Feierabend work, his later development of the correlates of political stability involved frequency occurrence counts and ratios for the politically highly stable and highly unstable nations.

Conclusions

Enough success in the application of factor analysis has been achieved in similar fields to suggest its utility to research in the arms-control field, and particularly to problems of local conflict control.

Studies employing this technique might lead to better selection among policy-action options aimed at the control of conflict. Eventually this research might permit the establishment of an operational center to monitor conflict potential in various nations of interest. The following research design suggests the steps that would be required to move in that direction. The initial stages are modest, and decisions about the detailed design--and even feasibility--of more elaborate undertakings would need to be re-examined after each effort. The research design should include:

- (1) A pilot factor analysis of the agreement analysis data, incorporating variables representative of the Rummel and Feierabend factors to:
 - (a) determine whether the agreement analysis result can be replicated by factor analysis;
 - (b) determine whether the Rummel and Feierabend factors are contained in the agreement analysis data;
 - (c) estimate the Rummel and Feierabend factor content of the agreement analysis clusters; and
 - (d) establish the research design for studies to follow.

In establishing the pilot study, a research planning conference is suggested, to include quantitatively oriented specialists from fields relevant to the substance to be studied, statisticians with extensive experience in factor analysis, and analysts who have applied factor analysis to cross-national data. In carrying out the pilot study, it will be important to retain the services of a qualified statistician (such as Al Beaton at E.T.S., Princeton, N.J.) both to help guide the pilot study and to assist in the design of the studies to follow.

- (2) A full factor analysis study to establish a descriptive categorization of various families of conflict behavior

patterns for both external and domestic conflict behavior by:

- (a) selecting appropriate variables based on the results of previous studies; and
 - (b) using techniques similar to those employed by Cattell and Hofstaetter.
- (3) A detailed analysis of the conflict content of each of the conflict behavior patterns identified in (2) above in order to:
- (a) identify the relevant correlates to conflict and determine which are independent variables or control elements in the conflict domain; and
 - (b) identify specific policy-action options that could be used in controlling conflict.
- (4) Determination of the best research technique to analyze the direct and indirect effects of selected policy action on the control elements in conflict; carrying out such a study to determine reliability of specific policy actions in producing the desired effects.
- (5) Analyses of the correlates of conflict to determine which are the best predictors of change in conflict situations.
- (6) In order to lessen duplication of data collection efforts, and in order to provide coherence between studies when the same variables are used and thus permit more valid comparison across studies, it is recommended that ACDA establish a data bank for use by researchers. In order to implement such a plan, ACDA could stipulate that, as a deliverable contract item, the contractor provide the data base used for the study. As a minimum the deliverable data should:

- (a) be submitted on punched cards according to a pre-determined format;
- (b) include the details at the lowest useful level of data (e.g., if the mean value for GNP across nations over a five-year period was used, both this value and GNP for each nation for each year would be included) and;
- (c) be documented as to source, method of collection, technique for aggregation, units of measure, etc.

It is recommended that high priority be given to a data base design project to specify the data format, methods for evaluating the reliability of data, storage and distribution techniques, documentation criteria, guidelines for the lowest level of useful aggregation by variable type, etc. The design should not, however, attempt to define what variables or sources are to be used. These choices should be left to the decision of the researcher.

After such a bank is established, the data could be made available to contractors on request.

It should be emphasized that the factor analytic technique cannot, any more than other techniques, produce a sure way for controlling conflict. It can, however, give better understanding of the conflict process, and may make it possible more effectively to apply policy action to bring about desired control of conflict. This would provide the basis for selection or evaluation of arms-control agreements that would have a desirable effect on our ability to control conflict. It is likely that more than one analytic technique will be employed in various studies.

APPENDIX

Data Sources for Various Factor Analysis Studies
(in order mentioned in text)*

- I. Barker, E. National Character, (London, Methuen, 1927)
- II. Gorier, G. The American People, (New York, Norton, 1948)
- III. Keyserling, H. A. Das Spektrum Europas, (Heidelberg, Kampmann, 1929)
- IV. de Madariaga, J. English, Frenchmen, and Spanish, (London, Oxford University Press, 1928)
- V. Masaryk, T. G. The Spirit of Russia, (London, Allen and Unwin, 1919)
- VI. McDougall, W. National Warfare and National Decay, (London, Methuen, 1921)
- VII. Mead, M. And Keep Your Powder Dry, (New York, Morrow, 1942)
- VIII. Toynbee, A. A Study of History, (New York, Oxford University Press, 1947)
- IX. Wissler, C. Man and Culture, (New York, Crowell, 1923)
- X. UNESCO
- XI. U.S. Department of State
- XII. Translation, by researchers, of psychological variables that are measurable
- XIII. Kiernan, J. Information Please Almanac, (New York, Macmillan, 1951)

*These sources are presented to give the reader a feeling for the accessibility of relevant data sources. If the references seem sketchy, it is because the researchers, in their documentation, were sketchy in their description of the sources used.

- XIV. U.S. Department of Commerce Statistical Abstracts of the U.S., 1948. (Washington, D.C., G.P.O., 1948)
- XV. U.N. Statistical Yearbook (early 1950s)
- XVI. U.N. Report on the World Social Situation, 1957
- XVII. U.N. Demographic Yearbook
- XVIII. U.N. Per Capita Income vs 70 Countries, 1949
- XIX. The Aging Population and Its Economic and Social Implications, 1956
- XX. Valaoras, Vasilios G. "Young and Aged Population," Annals of the American Academy of Political and Social Science, March 1958, pp. 69-83
- XXI. New York Times Index, various years
- XXII. New International Yearbook, various years
- XXIII. Facts on File, various years
- XXIV. Britannica Book of the Year, various years
- XXV. Eckstein, H. The Incidence of Internal Wars: The Problem of Anticipation, Report submitted to the Research Group in Psychology and Social Science, (Smithsonian Institution, Washington, D.C., January 15, 1962)
- XXVI. Deadline Data on World Affairs, various years

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